PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Akihiro GOTO, et al

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For: ELECTRODE FOR DISCHARGE SURFACE TREATMENT, MANUFACTURING METHOD FOR ELECTRODE FOR DISCHARGE SURFACE TREATMENT, DISCHARGE SURFACE TREATMENT APPARATUS, AND DISCHARGE SURFACE TREATMENT METHOD

SUPPLEMENTAL PRELIMINARY AMENDMENT

MAIL STOP AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Notice of Non-Compliant Amendment action dated May 18, 2007, please amend the above-identified application as follows on the accompanying pages.

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AMENDMENTS TO THE SPECIFICATION

Please delete the present Abstract of the Disclosure.

Please add the following new Abstract of the Disclosure:

An electrode is used for discharge surface treatment of a work piece. The electrode is made of a green compact obtained by compression-molding an electrode material including powder of any of a metal and a metallic compound, and the discharge surface treatment generating an electric discharge between the electrode and the work piece in an atmosphere of a machining medium and forming a film of a machining material on a surface of a work piece using energy produced by the electric discharge. The powder has an average particle diameter of not less than 10 nanometers and not more than 3 micrometers, and the electrode material of the electrode has substantially uniform composition and capable of forming a thick film with thickness not less than 100 micrometers.

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

Please cancel claims 1-59

60. (new): An electrode for discharge surface treatment of a work piece, the electrode being made of a green compact obtained by compression-molding an electrode material including powder of any of a metal and a metallic compound, and the discharge surface treatment generating an electric discharge between the electrode and the work piece in an atmosphere of a machining medium and forming a film of a machining material on a surface of a work piece using energy produced by the electric discharge, wherein

the powder has an average particle diameter of not less than 10 nanometers and not more than 3 micrometers, and the electrode material of the electrode has substantially uniform composition and capable of forming a thick film with thickness not less than 100 micrometers.

61. (new): The electrode according to claim 60, wherein the powder includes any one selected from a group essentially consisting of stellite, Ti-coated CBN, Tic+Ti, Cr_2C_3+Cr, Cr_2C_3+stellite, Al_2O_3+Ni, ZrO_2+Ni, and stellite+Co.

62. (new): The electrode according to claim 60, wherein particles of the powder have an aspherical shape.

63. (new): The electrode according to claim 62, wherein particles of the powder are any one of scaly and polygonal in shape.

64. (new): The electrode according to claim 60, wherein the powder has an average particle diameter of not less than 10 nanometers and not more than 1 micrometer.

65. (new): The electrode according to claim 64, wherein the powder contains any one of Co powder, Co alloy powder, Mo powder, Cr powder, W powder, Zr powder, Ta powder, Ti powder, V powder, and Nb powder.

66. (new): An electrode for discharge surface treatment of a work piece, the electrode being made of a green compact obtained by compression-molding an electrode material including powder of any of a metal and a metallic compound, and the discharge surface treatment generating an electric discharge between the electrode and the work piece in an atmosphere of a machining medium and forming a film of a machining material on a surface of a work piece using energy produced by the electric discharge, wherein

the powder includes a portion that has an average particle diameter of not less than 10 nanometers and not more than 3 micrometers, the portion being not less than 10% of total volume of the powder, and the electrode material of the electrode has both uniform composition and unit for hardness and is capable of forming a thick film with thickness not less than 100 micrometers.

67. (new): The electrode according to claim 66, wherein particles of a specific component of the powder have different particle diameters.

68. (new): The electrode according to claim 66, wherein the powder includes any one selected from a group essentially consisting of stellite, Ti-coated CBN, Tic+Ti, Cr_2C_3+Cr, Cr_2C_3+stellite, Al_2O_3+Ni, ZrO_2+Ni, and stellite+Co.

69. (new): The electrode according to claim 66, wherein the electrode material of the electrode is capable of forming a thick film with thickness not less than 100 micrometers, and the powder contains 80% or more of powder with an average value of particle diameters not less than 10 nanometers and not more than 1 micrometer as the electrode material.

70. (new): The electrode according to claim 69, wherein the powder contains any one of Co powder, Co alloy powder, Mo powder, Cr powder, W powder, Zr powder, Ta powder, Ti powder, V powder, and Nb powder.

71. (new): An electrode for discharge surface treatment of a work piece, the electrode being made of a green compact obtained by compression-molding an electrode material including powder of any of a metal and a metallic compound, and the discharge surface treatment generating an electric discharge between the electrode and the work piece in an atmosphere of a machining medium and forming a film of a machining material on a surface of a work piece

using energy produced by the electric discharge, wherein

the electrode material of the electrode has uniform hardness and is capable of forming a thick film with thickness not less than 100 micrometers, the powder is obtained by mixing a small-diameter powder having a distribution of small particle diameters and a large-diameter powder having an average particle diameter twice or more as large as the small-diameter powder, and the large-diameter powder is a mixture in 5 to 60 volume percent.

72. (new): The electrode according to claim 71, wherein the small-diameter powder is metal powder refined by grinding.

73. (new): The electrode according to claim 71, wherein the large-diameter powder has a substantially spherical shape.

74. (new): The electrode according to claim 71, wherein the powders to be mixed have an identical component.

75. (new): The electrode according to claim 71, wherein the powder is any one selected from a group consisting of Co alloy, Ni alloy, and Fe alloy.

76. (new): The electrode according to claim 71, wherein the large-diameter powder is in 5 to 20 volume percent.

77. (new): An electrode for discharge surface treatment of a work piece, the electrode being made of a green compact obtained by compression-molding an electrode material including powder of any of a metal and a metallic compound, and the discharge surface treatment generating an electric discharge between the electrode and the work piece in an atmosphere of a machining medium and forming a film of a machining material on a surface of a work piece using energy produced by the electric discharge, wherein

the electrode material of the electrode has uniform hardness and is capable of forming a thick film with thickness not less than 100 micrometers, the powder is obtained by mixing a small-diameter powder having a distribution of small particle diameters not more than 3 micrometers and a large-diameter powder having an average particle diameter not less than 5 micrometers, and the large-diameter powder is in 5 to 20 volume percent.

78. The electrode according to claim 77, wherein the small-diameter powder is metal powder refined by grinding.

79. (new): The electrode according to claim 77, wherein the large-diameter powder has a substantially spherical shape.

80. (new): The electrode according to claim 77, wherein the powders to be mixed have an identical component.

81. (new): The electrode according to claim 77, wherein the powder is any one selected from a group consisting of Co alloy, Ni alloy, and Fe alloy.

82. (new): The electrode according to claim 77, wherein the large-diameter powder is in 5 to 20 volume percent.

83. (new): A manufacturing method for an electrode for discharge surface treatment, comprising:

a first step of grinding powder of metal, a metallic compound, or ceramics into aspheric powder having a predetermined particle diameter and scaly shape with a grinder; and

a second step of compress-molding the powder ground into a predetermined shape to have predetermined uniform hardness.

84. (new): The manufacturing method according to claim 83, wherein the grinder is a mill apparatus.

85. (new): The manufacturing method according to claim 84, wherein the mill apparatus is any one of a ball mill apparatus, a bead mill apparatus, a vibrating mill apparatus, and a jet mill apparatus.

86. (new): The manufacturing method according to claim 84, wherein the mill apparatus includes a container and balls made of a same material as material of the powder to be ground.

87. (new): The manufacturing method according to claim 84, wherein the mill apparatus includes a container and balls with surfaces thereof subjected to build up welding, plating, or thermal spraying using a same material as a material of the powder to be ground.

88. (new): The manufacturing method according to claim 84, wherein a material of the mill apparatus is ZrO_2.

89. (new): The manufacturing method according to claim 83, wherein, in the first step, the predetermined particle diameter is not more than 3 micrometers.

90. (new): A method for discharge surface treatment of a work piece with an electrode, the electrode being made of a green compact obtained by compression-molding an electrode material including powder of any of a metal and a metallic compound, and the discharge surface treatment generating an electric discharge between the electrode and the work piece in an atmosphere of a machining medium and forming a film of a machining material on a surface of a work piece using energy produced by the electric discharge, comprising:

forming the film using a uniform electrode obtained by compression-molding powder with an average value of particle diameters not less than 10 nanometers and not more than 3 micrometers by using electrode material that is capable of forming a thick film with thickness not less than 100 micrometers.

91. (new): The method according to claim 90, wherein the powder has an average value of particle diameters not less than 10 nanometers and not more than 1 micrometer.

92. (new): The method according to claim 91, wherein

the electrode and the work piece are arranged in a machining fluid or a predetermined gas atmosphere, and

electric discharge is performed in the machining fluid or the predetermined gas atmosphere.

93. (new): The method according to claim 91, wherein a pulse current with a discharge pulse width not more than 70 microseconds and a peak current value not more than 30 amperes is supplied between the electrode and the work piece.

94. (new): The method according to claim 91, wherein the powder is powder of metal, a metal compound, or ceramics.

95. (new): A method for discharge surface treatment of a work piece with an electrode, the electrode being made of a green compact obtained by compression-molding an electrode material including powder of any of a metal and a metallic compound, and the discharge surface treatment generating an electric discharge between the electrode and the work piece in an

atmosphere of a machining medium and forming a film of a machining material on a surface of a work piece using energy produced by the electric discharge, comprising:

forming the film using an electrode having uniform composition and hardness and obtained by compression-molding powder mixed with powder having a particle diameter not less than 10 nanometers and not more than 3 micrometers mixed in a proportion not less than 10% in the powder, and using electrode material that is capable of forming a thick film with thickness not less than 100 micrometers.

96. (new): The method according to claim 95, wherein the electrode contains 80% or more of powder having an average value of particle diameters not less than 10 nanometers and not more than 1 micrometer.

97. (new): The method according to claim 96, wherein

the electrode and the work piece are arranged in a machining fluid or a predetermined gas atmosphere, and

electric discharge is performed in the machining fluid or the predetermined gas atmosphere.

98. (new): The method according to claim 96, wherein a pulse current with a discharge pulse width not more than 70 microseconds and a peak current value not more than 30 amperes is

supplied between the electrode and the work piece.

99. (new): The method according to claim 96, wherein the powder is powder of metal, a metal compound, or ceramics.

100. (new): A method for discharge surface treatment of a work piece with an electrode, the electrode being made of a green compact obtained by compression-molding an electrode material including powder of any of a metal and a metallic compound, and the discharge surface treatment generating an electric discharge between the electrode and the work piece and forming a film of a machining material on a surface of a work piece using energy produced by the electric discharge, comprising:

forming the film by using a uniform electrode obtained by mixing a small-diameter powder having a distribution of small particle diameters and a large-diameter powder having an average particle diameter twice or more as large as the small-diameter powder and compression-molding the powders, the large-diameter powder being in 5 to 60 volume percent, and by using electrode material that is capable of forming a thick film with thickness not less than 100 micrometers.

101. (new): The method according to claim 100, wherein the small-diameter powder is powder refined by grinding.

102. (new): The method according to claim 100, wherein the large-diameter powder has a substantially spherical shape.

103. (new): The method according to claim 100, wherein the small-diameter particle and the large-diameter particle have an identical component.

104. (new): The method according to claim 100, wherein the powder is any one of Co alloy, Ni alloy, and Fe alloy.

105. (new): The method according to claim 100, wherein the large-diameter powder is in 5 to 20 volume percent.

106. (new): The method according to claim 100, wherein

the electrode and the work piece are arranged in a machining fluid or a predetermined gas atmosphere, and

electric discharge is performed in the machining fluid or the predetermined gas atmosphere.

107. (new): The method according to claim 100, wherein a pulse current with a discharge pulse width not more than 70 microseconds and a peak current value not more than 30 amperes is supplied between the electrode and the work piece.

108. (new): A method for discharge surface treatment of a work piece with an electrode, the electrode being made of a green compact obtained by compression-molding an electrode material including powder of any of a metal and a metallic compound, and the discharge surface treatment generating an electric discharge between the electrode and the work piece and forming a film of a machining material on a surface of a work piece using energy produced by the electric discharge, comprising:

forming the film by using a uniform electrode obtained by mixing a small-diameter powder having a distribution of small particle diameters not more than 3 micrometers and a large-diameter powder having an average particle diameter not less than 5 micrometers and compression-molding the powders, the large-diameter powder being in 5 to 60 volume percent, and by using electrode material that is capable of forming a thick film with thickness not less than 100 micrometers.

109. (new): The method according to claim 108, wherein the small-diameter powder is powder refined by grinding.

110. (new): The method according to claim 108, wherein the large-diameter powder has a substantially spherical shape.

111. (new): The method according to claim 108, wherein the small-diameter particle and the large-diameter particle have an identical component.

112. (new): The method according to claim 108, wherein the powder is any one of Co alloy, Ni alloy, and Fe alloy.

113. The method according to claim 108, wherein the large-diameter powder is in 5 to 20 volume percent.

114. (new): The method according to claim 108, wherein

the electrode and the work piece are arranged in a machining fluid or a predetermined gas atmosphere, and

electric discharge is performed in the machining fluid or the predetermined gas atmosphere.

115. (new): The method according to claim 108, wherein a pulse current with a discharge pulse width not more than 70 microseconds and a peak current value not more than 30 amperes is supplied between the electrode and the work piece.

116. (new): A discharge surface treatment apparatus that has an electrode consisting of a green compact obtained by compression-molding powder of metal or a metallic compound and a work

piece on which a film is formed, the electrode and the work piece being arranged in a machining fluid or in an air, generates a pulsed electric discharge between the electrode and the work piece using a power supply apparatus electrically connected to the electrode and the work piece, and forms, using discharge energy of the electric discharge, a film consisting of an electrode material or a substance generated by reaction of the electrode material due to the discharge energy on a surface of the work piece, wherein

the powder has an average particle diameter of not less than 10 nanometers and not more than 3 micrometers, and the electrode material of the electrode has substantially uniform composition and capable of forming a thick film with thickness not less than 100 micrometers.

117. (new): The discharge surface treatment apparatus according to claim 116, wherein powder with an average value of particle diameters not less than 10 nanometers and not more than 1 micrometer is used.

118. (new): The discharge surface treatment apparatus according to claim 117, wherein

the electrode and the work piece are arranged in a machining fluid or a predetermined gas atmosphere, and

electric discharge is performed in the machining fluid or the predetermined gas atmosphere.

119. (new): The discharge surface treatment apparatus according to claim 117, wherein a pulse current with a discharge pulse width not more than 70 microseconds and a peak current value not more than 30 amperes is supplied between the electrode and the work piece.

120. (new): The discharge surface treatment method according to claim 117, wherein the powder is powder of metal, a metal compound, or ceramics.

121. (new): A discharge surface treatment apparatus that has an electrode consisting of a green compact obtained by compression-molding powder of metal or a metallic compound and a work piece on which a film is formed, the electrode and the work piece being arranged in a machining fluid or in an air, generates a pulsed electric discharge between the electrode and the work piece using a power supply apparatus electrically connected to the electrode and the work piece, and forms, using discharge energy of the electric discharge, a film consisting of an electrode material or a substance generated by reaction of the electrode material due to the discharge energy on a surface of the work piece, wherein

the powder includes a portion that has an average particle diameter of not less than 10 nanometers and not more than 3 micrometers, the portion being not less than 10% of total volume of the powder, and the electrode material of the electrode has both uniform composition and unit for hardness and is capable of forming a thick film with thickness not less than 100 micrometers.

122. (new): The discharge surface treatment apparatus according to claim 121, wherein the electrode contains 80% or more of powder having an average value of particle diameters not less than 10 nanometers and not more than 1 micrometer.

123. (new): The discharge surface treatment apparatus according to claim 122, wherein

the electrode and the work piece are arranged in a machining fluid or a predetermined gas atmosphere, and

electric discharge is performed in the machining fluid or the predetermined gas atmosphere.

124. (new): The discharge surface treatment apparatus according to claim 122, wherein a pulse current with a discharge pulse width not more than 70 microseconds and a peak current value not more than 30 amperes is supplied between the electrode and the work piece.

125. (new): The discharge surface treatment method according to claim 122, wherein the powder is powder of metal, a metal compound, or ceramics.

126. (new): A discharge surface treatment apparatus comprising:

an electrode consisting of a green compact obtained by compression-molding powder of metal or a metal compound;

a work piece on which a film is formed; and

a power supply apparatus electrically connected to the electrode and the work piece,

the discharge surface treatment apparatus generating pulse-like electric discharge between the electrode and the work piece with the power supply apparatus and forming, using discharge energy of the discharge, a film consisting of an electrode material or a substance generated by reaction of the electrode material due to the discharge energy on a surface of the work piece, wherein

a uniform electrode is manufactured from an electrode material that is obtained by mixing a small-diameter powder having a distribution of small particles and a large-diameter powder having an average particle diameter twice or more as large as the small-diameter powder, the large-diameter powder being in 5 to 60 volume percent, and the electrode material being capable of forming a thick film with thickness not less than 100 micrometers.

127. The discharge surface treatment apparatus according to claim 126, wherein the small-diameter powder is powder refined by grinding.

128. (new): The discharge surface treatment apparatus according to claim 126, wherein the large-diameter powder has a substantially spherical shape.

129. (new): The discharge surface treatment apparatus according to claim 126, wherein the small-diameter particle and the large-diameter particle have an identical component.

130. (new): The discharge surface treatment apparatus according to claim 126, wherein the powder is any one of Co alloy, Ni alloy, and Fe alloy.

131. (new): The discharge surface treatment apparatus according to claim 126, wherein the large-diameter powder is in 5 to 60 volume percent.

132. (new): The discharge surface treatment apparatus according to claim 126, wherein the large-diameter powder is in 5 to 20 volume percent.

133. (new): The discharge surface treatment apparatus according to claim 126, wherein

the electrode and the work piece are arranged in a machining fluid or a predetermined gas atmosphere, and

electric discharge is performed in the machining fluid or the predetermined gas atmosphere.

134. (new): The discharge surface treatment apparatus according to claim 126, wherein a pulse current with a discharge pulse width not more than 70 microseconds and a peak current value not more than 30 amperes is supplied between the electrode and the work piece.

135. (new): A discharge surface treatment apparatus comprising:

an electrode consisting of a green compact obtained by compression-molding powder of

metal or a metal compound;

a work piece on which a film is formed; and

a power supply apparatus electrically connected to the electrode and the work piece,

the discharge surface treatment apparatus generating pulse-like electric discharge between the electrode and the work piece with the power supply apparatus and forming, using discharge energy of the discharge, a film consisting of an electrode material or a substance generated by reaction of the electrode material due to the discharge energy on a surface of the work piece, wherein

a uniform electrode is manufactured from an electrode material that is obtained by mixing a small-diameter powder having a distribution of small particles not more than 3 micrometers and a large-diameter powder having an average particle diameter not less than 5 micrometers, the large-diameter powder being in 5 to 60 volume percent, and the electrode material being capable of forming a thick film with thickness not less than 100 micrometers.

136. (new): The discharge surface treatment apparatus according to claim 135, wherein the small-diameter powder is powder refined by grinding.

137. (new): The discharge surface treatment apparatus according to claim 135, wherein the large-diameter powder has a substantially spherical shape.

138. (new): The discharge surface treatment apparatus according to claim 135, wherein the small-diameter particle and the large-diameter particle have an identical component.

139. (new): The discharge surface treatment apparatus according to claim 135, wherein the powder is any one of Co alloy, Ni alloy, and Fe alloy.

140. (new): The discharge surface treatment apparatus according to claim 135, wherein the large-diameter powder is in 5 to 60 volume percent.

141. (new): The discharge surface treatment apparatus according to claim 135, wherein the large-diameter powder is in 5 to 20 volume percent.

142. (new): The discharge surface treatment apparatus according to claim 135, wherein

the electrode and the work piece are arranged in a machining fluid or a predetermined gas atmosphere, and

electric discharge is performed in the machining fluid or the predetermined gas atmosphere.

143. (new): The discharge surface treatment apparatus according to claim 135, wherein a pulse current with a discharge pulse width not more than 70 microseconds and a peak current value not more than 30 amperes is supplied between the electrode and the work piece.